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THE PATTERN DISCRIMINATION TASK

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SUMMARY

The performance of two subjects on a pattern discrimination task was evaluated during a 7-day confinement in a small capsule. The subjects were on a 4-hour-on, 4-hour-off duty cycle, with one subject on duty at all times. The patterns were presented in two sessions, one at the beginning and one at the end of the on-duty shift. Approximately 150 pattern discriminations were required of each subject during each session. Comparisons are made between performances from session to session within a shift, between shifts, and over days. The percent error of pattern discriminations is used to provide a quantitative measure of the quality of performance.

The quality of performance improved during the early portion of the confinement and declined during the latter portion.

Subject S's performance was affected by time of day. His best performance was on the evening shifts, next best on the night shifts, and poorest on the day shifts. The effect was stronger at the beginning of confinement, and disappeared toward the end. Subject R's performance did not vary significantly with time of day.

Comparison of data taken at the beginning and end of each shift shows a within-shift decrement for subject R that was uniform over days of confinement. For the first days of the confinement, subject S showed a within-shift improvement, but a within-shift decrement at the end.

The hypothesis that under unfavorable conditions of day, shift or session, difficult discriminations would suffer relatively greater decrements than easy discriminations was not confirmed.

Performance of the task was maintained at what appears to be a reasonably high level throughout the 7-day confinement. This result indicates that under the conditions of this study proficiency in a pattern discrimination task can be maintained in a small capsule.

INTRODUCTION

The accomplishment of manned missions into space and plans for more elaborate ventures in the future have increased interest in human response to various unusual situations and operating conditions that will exist. Necessary restrictions of payload weight and size indicate that the extent of bodily movements and of the perceptual field may be so restricted that performance will degenerate. Studies of human response to confinement have been performed in various laboratories (refs. 1 to 9). The crew compartment habitability study conducted at the Ames Research Center, of which the testing procedures reported here were a part, was unique in that the confinement capsule realistically simulated, in size and general arrangement, a two-man space vehicle such as is proposed for near future missions, and closely evaluated a wide variety of behavioral and physiological indices. A description of the habitability study, including its rationale, the procedures employed, and a summary of the results of the various testing procedures, has been presented (ref. 10).

Table I presents a typical on-duty work schedule employed in the study. Seven different performance tasks, indicated in table I by asterisks, were administered sequentially during each duty period. These were selected to represent a typical workload for a 7-day lunar mission. Since these performance tasks were administered independently, each constitutes a separate subexperiment within the over-all testing procedure. In addition to the task reported here, the information processing task has been reported in detail (ref. 11). For convenience, descriptions of the general procedures used in the Ames habitability study have been described in both reports.

In the operation of man-machine systems, such as manned space vehicles, the operator is commonly presented information necessary for system control through the medium of visual displays. Such displays take many forms. A typical task may require that the operator view and interpret patterns of stimuli within the display field. A pattern discrimination task was used in a previous habitability study (ref. 1) employing a much larger living and working area. In that study, performance was shown to improve steadily over the 4-day confinement.

Investigators have generated dot-patterns by selecting elements from a matrix of potential stimulus elements. Such a procedure allows precise control of various aspects of the resulting patterns and is convenient to instrument. For example, French (refs. 5 and 6), in studying the effect of pattern complexity upon ease of pattern identification, presented subjects with arrays of 2 to 7 dots, paired sequentially, half of the pattern pairs consisting of two identical patterns, and half differing slightly. The latter condition was produced by varying the position of one dot in the second pattern from its position in the first pattern. The subject's task was to state whether pattern pairs were "same" or "different." His results suggested that the quality of the subject's performance varied according to the proportion of changes in inter-dot relationships introduced by the displacement.

The present investigation was an extension of pattern discrimination studies reported in the literature and was concerned with the subjects' ability to make accurate responses to patterned stimulus material during confinement in a compartment simulating the size and general arrangement of a small crew compartment of a space vehicle.

PROCEDURE

General

Two subjects were enclosed for 7 days in a cone-shaped capsule of approximately 123 cubic feet of usable volume. The capsule contained two seats. One of these could be reclined to provide a cot for the off-duty subject. One subject at a time could stand behind the seats and exercise moderately. Except for volume, all physical aspects of the environment (heat, ventilation, illumination, etc.) accorded with usual requirements for human comfort. Some insulation was provided to diminish noises from the outside environment. The illumination level of the compartment was controlled by the subjects.

Duty cycles were an alternating 4 hours on, 4 hours off, with one subject on duty at all times while the other rested. On-duty shifts were:

12 Noon - 4 P.M.	Subject S, Day shift
4 P.M. - 8 P.M.	Subject R, Evening shift
8 P.M. - 12 Midnight	Subject S, Evening shift
12 Midnight - 4 A.M.	Subject R, Night shift
4 A.M. - 8 A.M.	Subject S, Night shift
8 A.M. - 12 Noon	Subject R, Day shift

Various performance tasks were given the on-duty subject (table I). Tasks requiring information processing, the estimation of the rate of a pointer movement, assessment of mission status, vigilance, pattern discrimination, navigation computation, and tracking were administered. The total time required for these procedures was slightly over 3 hours of the 4-hour duty period.

Pattern Discrimination Task

Patterns were presented by lighting chosen elements within a six by six matrix of lamps. Patterns appeared in pairs; the presentation of a pair of patterns and the subject's response to them constituted one trial. A standard pattern was presented (0.2-sec duration), followed by an interval in which no pattern appeared (3.0 sec). The second comparison pattern was then presented (0.2 sec), followed by an interval (6.0 sec) in which no pattern appeared. During this 6-second interval, the subject indicated by pushing one of two buttons on the instrument panel, whether he judged the comparison pattern to be the same as the standard pattern or different. At the end of the 6-second interval, a new trial was begun with presentation of the standard pattern for the next pattern pair. Approximately 150 trials constituted a 25-minute session. Thus each subject viewed approximately 6,300 pattern pairs during the 7-day confinement.

The patterns were generated automatically by a digital computer (IBM 7090), according to rules furnished by the experimenter, and entered into the computer program. A new tape was generated for every session.

1. The starting element (light) in the matrix was randomly chosen.

2. Each subsequent element in the pattern was placed by the execution of a "random walk" until the requisite number was attained. The number of pattern elements varied randomly from trial to trial, although it was always the same for the two members of a pattern pair. The number of elements was 3, 4, 5, 6, or 7.

3. The choice of adjoining cells was not permitted nor could two or more cells intervene between elements. Distance between adjacent elements was thus held constant at one space except in instances of diagonals where it increased slightly. Thus, the average interelement distance was relatively constant.

4. The "different" pattern was rendered different by relocating one element in the pattern. The element to be moved was randomly chosen. Its direction of movement was also chosen randomly from among the possible directions and it moved only one space into an unoccupied matrix cell, never violating the minimum distance requirement in 3, above. However, it was allowed, if necessary, to move farther than one space from its immediate neighbor.

5. To increase task difficulty, every comparison pattern was rotated 180° from the position of the standard.

6. The order of pattern size presentation and whether the comparison pattern was to be "same" or "different" were randomly determined. Every standard pattern was compared with both a "same" or "different" pattern at one time or another during the study, however. That is, a pattern with which the computer had matched a "same" or "different" comparison was stored and later used with a "different" or "same" comparison pattern, as appropriate.

Instrumentation

For task presentation, the computer-generated punched paper tapes were fed into an Electronic Engineering TR-480 reader. This device reads an 8x10 block of cells simultaneously. Patterns were read and corresponding lights were activated on a matrix of lamps in the desired temporal sequence. Timing was accomplished by synchronous-motor-driven cams actuating microswitches.

A General Electric Vidicon was focused on the matrix, and the patterns were presented to the subjects on a television screen within the capsule. The subjects had no control over the characteristics of the picture. The picture was adjusted initially by the experimenters while viewing a monitor screen outside the capsule to which the subject's screen was slaved. The controls were not touched again for the duration of the study. Focus was adjusted by the experimenters, and a fully closed iris setting was used for all sessions. This provided a uniformly gray background for the white appearing dot patterns. The dots were approximately 4 millimeters in diameter and the pattern field was a

10X10 centimeter square. Viewing distance was 29 inches. The matrix itself, the unactivated lights, and other visual cues related to the matrix hardware were not viewed by the subjects. They saw only a pattern of white dots appearing at the center of the screen against the gray field.

The punched paper tape was coded with information designating pattern size, and whether the pattern pair was in fact the same or different. When the subject responded by activating one of his two buttons, the resulting signal was compared with the same-different signal from the tape reader. Agreement between the subject and tape reader, or disagreement, was recorded as a pen deflection on a strip chart recorder. Different voltages were assigned the pattern sizes (3, 4, 5, 6, 7) and these were indicated by the deflection of another pen. Only the TV monitor and response buttons were located within the capsule.

RESULTS AND DISCUSSION

Quality of performance is expressed as percentage-of-error scores, that is, the percentage of the total responses under a given condition which were incorrect. Statistical significance of observed differences in means was tested by nonparametric methods. The tests used were the Mann-Whitney U Test and the Friedman Two-Way Analysis of Variance by Ranks.

The Mann-Whitney U Test (ref. 14, pp. 116-127) develops a statistic (z) which allows a statement of the probability (p) that two independent samples could have been drawn from the same population.

The Friedman Two-Way Analysis of Variance (ref. 14, pp. 166-172) develops a statistic (x_r^2) which allows a statement of the probability (p) that k (3 or more) samples could have been drawn from the same population. The value of p for a given x_r^2 is a function of the number of degrees of freedom (df) with df = k - 1.

Since the response recording apparatus was not reliable during the first day, the scores for the first three shifts of each subject could not be used in the analysis. Base-line data, secured on the day prior to confinement, showed an error rate of approximately 20 percent. Since the amount of the data secured was small and conditions were not well controlled, the 20-percent figure is not considered reliable.

Total Error

The mean error (both subjects under all conditions) is 8.7 percent. Subject R's mean error is 8.3 percent; subject S's is 9.1 percent. The difference between these subject means is not statistically significant (U test, z = 1.27, N.S.).

Day-by-Day Performance

Figure 1 presents the error scores, separately for subjects, for each day of the confinement. Each point represents the mean error for the six testing sessions (two sessions during each of three shifts) of the particular day. In general, performance tended to improve during the early days of the confinement, and become slightly worse toward the end. Subject R's data exhibit a much more regular trend than do subject S's. The significance of the observed differences was tested by comparing the scores on days 2 and 3, with 4 and 5, and with 6 and 7, the particular division reflecting the general U-shape of the curves. Significance was established for the day-to-day differences in the subjects' combined scores (Friedman test: $x_r^2 = 9.3$, df = 2, $p < 0.02$). Individually, subject R's scores show a significant over-all variation over days (Friedman test: $x_r^2 = 5.9$, df = 2, $p < 0.05$), but subject S's do not (Friedman test: $x_r^2 = 4.7$, df = 2, p between 0.05 and 0.10).

Effects of Time of Day

Figure 2 presents the mean percentage of error score as a function of the time of day (day, evening, or night shift) at which the data were recorded, with data for all days combined. Means for each subject, and for the subjects' data combined are shown. It will be seen that there was some variation in performance related to time of day, with a tendency for relatively poor performance to occur during the day shift, better during the night, and best during the evening shift. While the differences seem small, they are shown to be significant for the combined data (Friedman test: $x_r^2 = 6.1$, df = 2, $p < 0.05$), although not for either subject's data alone (Friedman test: subject R, $x_r^2 = 1.99$, df = 2, N.S.; subject S, $x_r^2 = 5.16$, df = 2, p between 0.10 and 0.05). However, it seems indicated that most of the variation in performance associated with shift can be attributed to subject S.

The reason for the particular hierarchy of shifts cannot be determined from the data. One possible explanation is that the greater general activity during the day (i.e., the off-duty subject awake and converse with the on-duty subject, and a greater volume of conversation between the subjects and experimenters) was distracting, and influenced performance adversely. It might be fruitful to include amount of distraction as an experimental variable in future studies of this kind.

Particular interest existed in discovering any interactive effects of shift versus duration of confinement. That is, as the confinement progressed, would any observed differences in performance related to shift tend to increase, decrease, or remain the same? Figure 3 presents the shift-related mean percentage of error scores separately for the test. The Friedman test was applied to these data (table II). While the x_r^2 associated with subject R's scores on the last two days is somewhat higher than those for days 2-3 and 4-5, the obtained value falls far short of that required for significance. Subject S's data show a trend of decreasing effect of shift with the passage of time. In his case it can be stated that the effects of shift tended to disappear as the confinement progressed.

Within-Shift Changes

In order to evaluate within-shift changes, the scores obtained from the sessions at the beginning of shifts were compared with those from sessions at the end of shifts. Figure 4 shows, by days, the errors made by each subject on the second session of the shift, as a percentage of the total errors for both sessions. Each point is a mean percentage of error score for a particular subject, combining all shifts for that day. A relatively high position on the figure means that performance declined on the average over the course of the shifts on that day, while a relatively low position means that performance improved. The 50-percent line represents no change from the first sessions to the second.

Over-all (combining the data for all days), subject S's performance tended to improve during the late session compared with the early, 45.1 percent of his total error occurring during the late session of the shifts. This difference is not statistically significant, however (U test: $z = 0.90$, N.S.). Subject R's performance tended to worsen over shift, his comparable mean error being 54.4 percent (U test: $z = 1.69$, $p < 0.05$).

Trends over the course of confinement are quite different for the two subjects. Subject R's within-shift decrement did not vary significantly over days (Friedman test: $x_r^2 = 1.26$, df = 5, N.S.). Subject S's performance tended to improve during the shift for the first 3 days of the confinement (days 2, 3, and 4, M = 37.9), but worsen during the last 3 (M = 52.3). The change over days is statistically significant (Friedman test: $x_r^2 = 11.35$, df = 5, $p < 0.05$).

Effect of Varying Pattern Size

Figure 5 plots each subject's percentage of error and the percentage of error for the two subjects' data combined, as a function of pattern size. The form of the curve is as expected (refs. 2 and 3), with a linear increase in error to a pattern size of six dots, and a steeper rise to seven (combined data). The variation across pattern size is highly significant for both subjects (Friedman test: subject R, $x_r^2 = 32.0$, df = 4, $p < 0.001$; subject S, $x_r^2 = 34.1$, df = 4, $p < 0.001$).

The primary reason for including pattern size as an experimental variable was to test the hypothesis that interactive effects would be observed related to the number of dots in the pattern (variation in task difficulty) and variables influencing the over-all level of performance during a session. It might be expected that performance decrements associated with time of day, with days of confinement or occurring during a shift, would be greater in magnitude for the more difficult patterns. Inspection and analysis of the data failed to reveal any such interaction.

General Evaluation of Performance

While some variation in the quality of performance was observed, related to duration of confinement, time of day, and on-duty activities, it is thought that performance over-all remained satisfactory. Variations from the over-all mean error due to particular conditions (other than pattern size) were small, and in no sense did performance "break down" at any time. Differences between the present experimental situation and the actual operational situation suggest that in the latter case better performance might be expected, due to greater motivation existing in the real situation. Factors, such as the lack of realism in the task and the lack of feedback concerning the adequacy of the performance, suggest that the present situation may represent a worst case from the motivation standpoint, and that the generally good performance can be considered encouraging. It is believed that the results of this task support the conclusion that the capsule configuration tested is habitable, under the conditions of this experiment, since proficiency in a pattern discrimination task was maintained during a 7-day continuous occupancy.

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National Aeronautics and Space Administration
Moffett Field, Calif., April 26, 1963

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TABLE I.- SAMPLE WORK SCHEDULE

Shift No. 20
Monday, April 2, 1962
Subject R on duty

4:00 P.M.	Medical monitoring
4:15	*Rate estimation
4:35	*Vigilance
4:45	*Pattern discrimination
5:10	*Mission status monitoring
5:15	*Navigation
6:10	Rest period
6:25	*Tracking
6:45	*Information processing
7:15	*Vigilance
7:25	*Pattern discrimination
7:50	Rest
8:00	Off-duty period begins

*Performance tasks

TABLE II.- RESULTS OF THE FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE, TESTING SHIFT DIFFERENCES SEPARATELY FOR DAYS 2-3, 4-5, AND 6-7 OF THE CONFINEMENT

		x_r^2	p*
Subject R - Days	2-3	0.5	N.S.
	4-5	0.5	N.S.
	6-7	3.15	N.S.
Subject S - Days	2-3	6.5	0.042
	4-5	4.5	0.125
	6-7	0.5	N.S.

*In all cases, exact probabilities with k = 3, N = 4 are used (see ref. 14, p. 280).

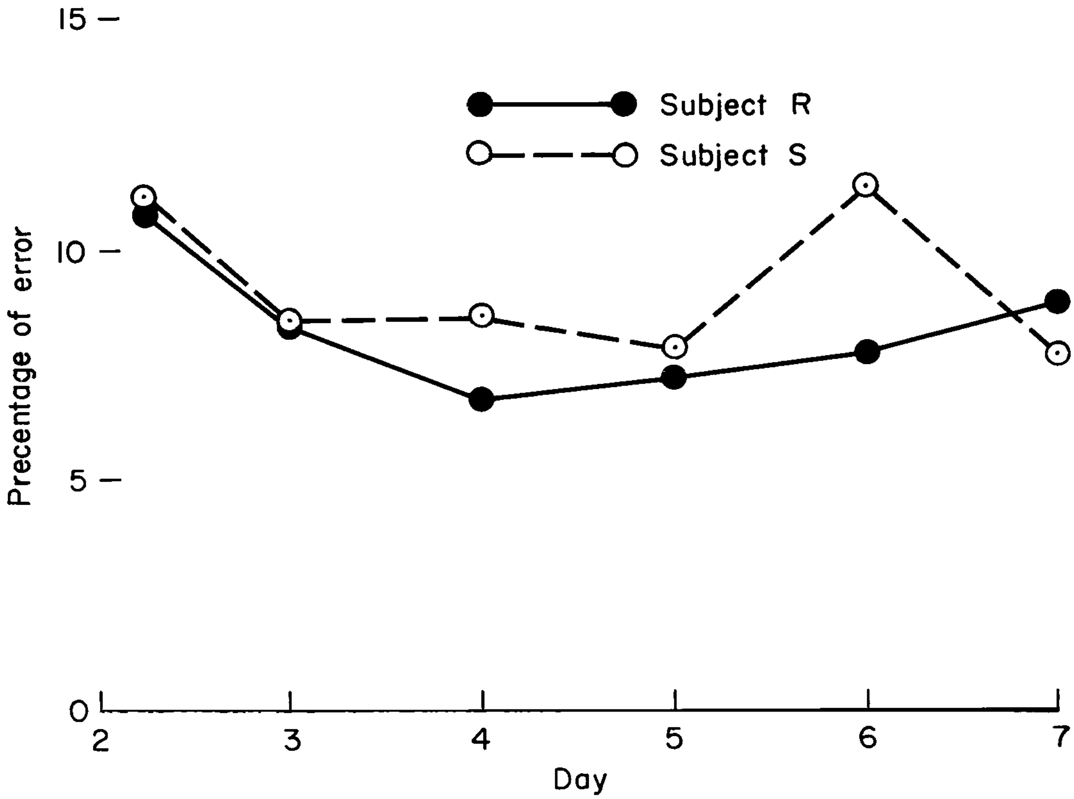

Figure 1.- Mean percentage of error by days. Each point represents a subject's mean score for six sessions (three shifts, two sessions each).

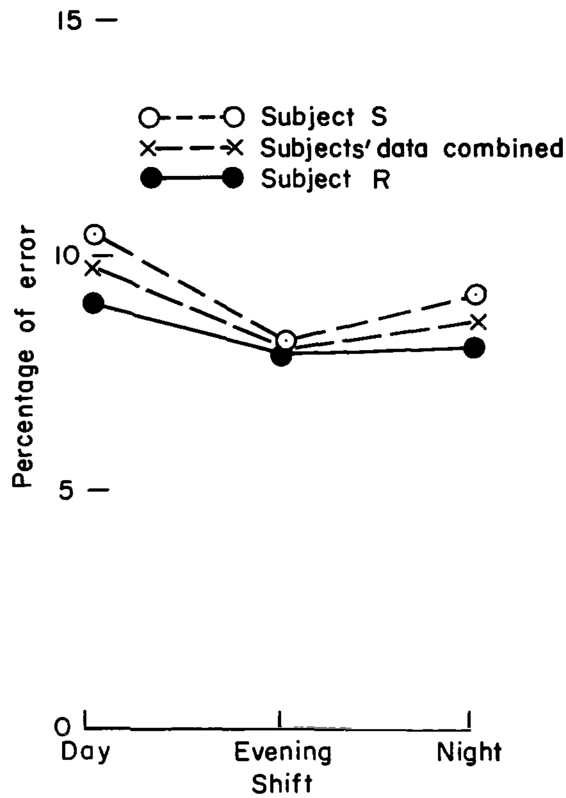

Figure 2.- Mean percentage of error by shift. Data for all days are combined.

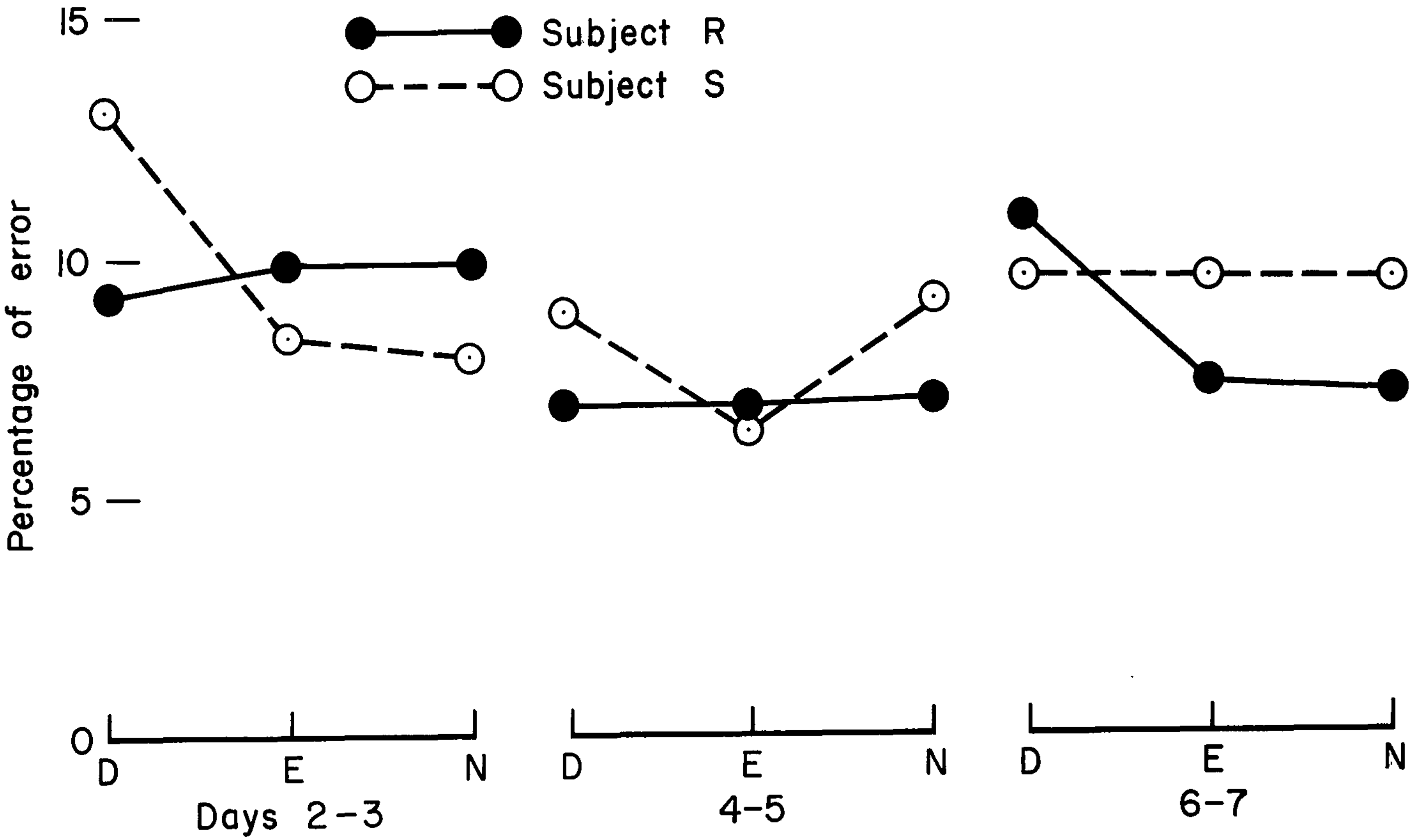

Figure 3.- Mean percentage of error by shift. Data for days 2-3, 4-5, and 6-7 are presented separately.

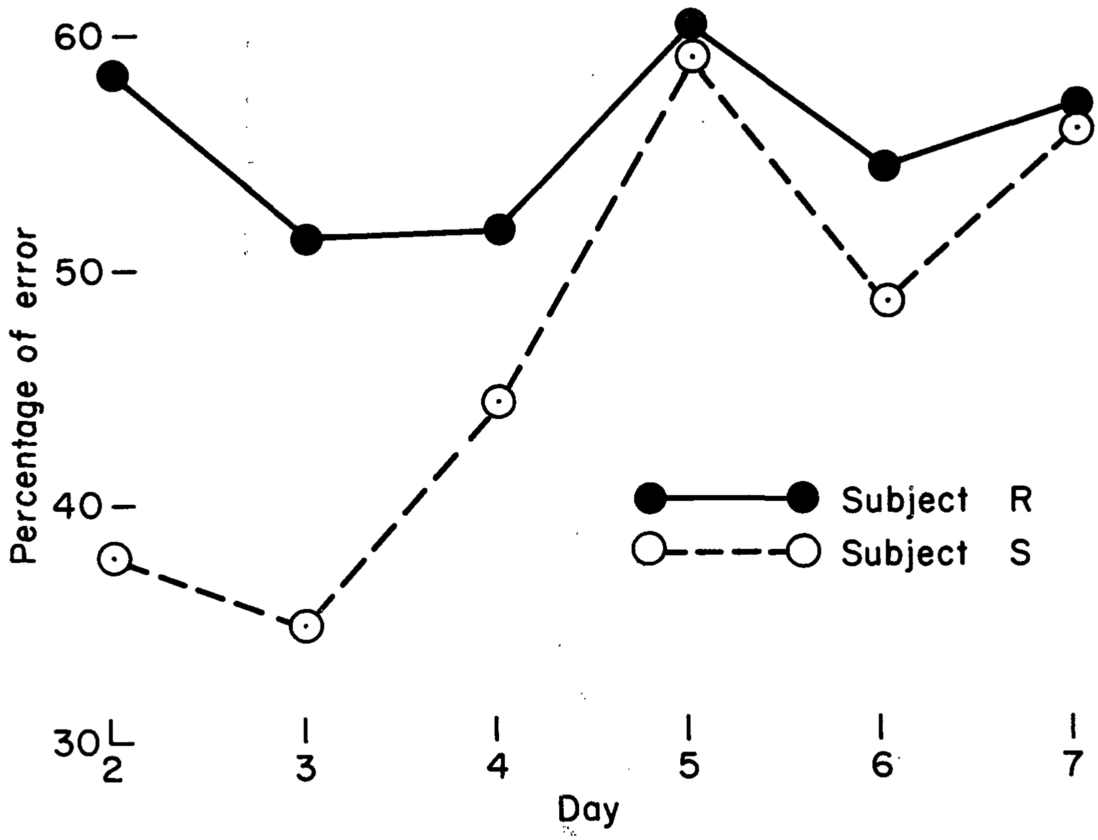

Figure 4.- Error associated with the second session of shifts as a percentage of the total error made on both sessions. Each point is a mean percentage of error score for a subject, combining all shifts for a given day.

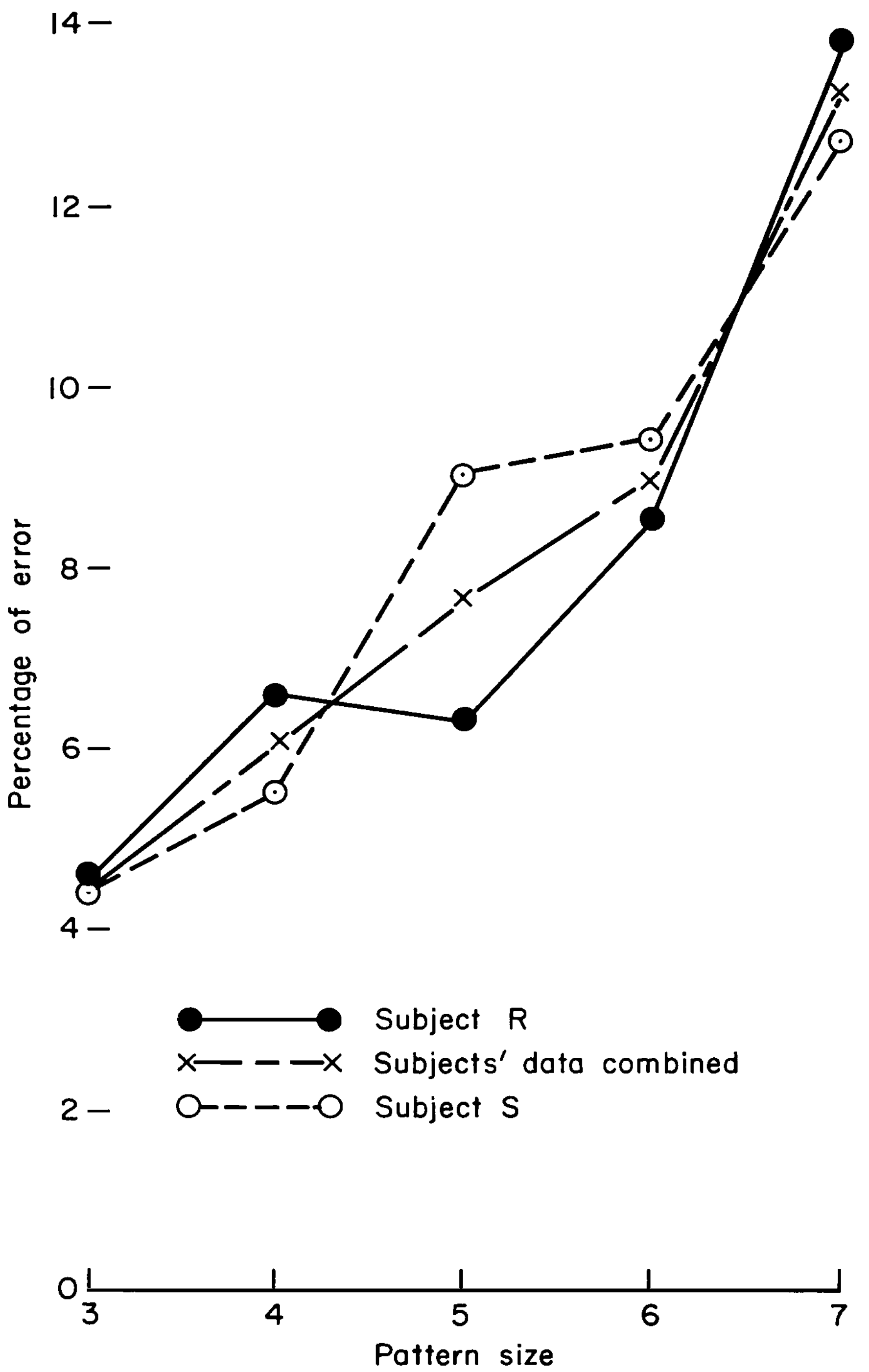

Figure 5.- Mean percentage of error as a function of pattern size. Data for all shifts are combined.